The purpose of the Morgantown PRT ~~Project~~ Project is to develop and demonstrate ~~this~~ a new concept of transportation ~~to which we refer to as Personal~~

UMTA's

With the Morgantown Project, UMTA has taken a bold step forward not only in utilizing new technology for transit but by implementing a full-scale system to demonstrate operational and economic feasibility, something which is not being done anywhere else. The goal is to make this new system eligible for UMTA capital grants program throughout the nation and to make the design available to all qualified parties on a non-proprietary basis.

The PRT concept requires innovative features such as small cars, short headways (intervals between cars), off-line station, automatic controls (computers), automatic merging and de-merging, fast acting switching capability and dedicated guideways, in order to be a viable transportation system.

The Urban Mass Transportation Administration was interested ~~looking to find~~ find a suitable geographical location to demonstrate such a system, in an urban environment rather than in a remote site. ~~and found~~ The University of West Virginia at Morgantown ~~having~~ was ~~the~~ willingn~~ess~~ to provide the right-of-ways necessary for the construction of the guideway ~~such a system~~. The University will take this prototype system and make it operational by acquiring additional vehicles through a capital grant application to UMTA which is on a 1/3 to 2/3 basis.

INTRODUCTION

The purpose of the Morgantown project is to develop and demonstrate a new concept of transportation referred to as a Personal Rapid Transit (PRT) System, featuring fully automatic self-service. The intent is to prove the technical feasibility as well as the economic viability of this new transportation concept which is designed to transport people faster, safer and more conveniently than existing systems while at the same time alleviating congestion, noise and air pollution associated with existing ground transportation systems.

The PRT concept requires innovative features such as small cars, short headway (intervals between cars), off-line stations, automatic, i. e. computer controlled merging and demerging, fast acting switching capability and a dedicated guideway in order to be a viable transportation system. The following discussions will address questions relative to the PRT demonstration and these innovations.

1. Background
2. Why PRT systems?
3. Why Morgantown?
4. What has the Program Management Office (PMO) done to reduce cost?

a. Eliminated certain requirements from both the R&D and capital grant portion.

b. Reduced requirements.

c. Deferred some requirements from R&D portions but made them part of the capital grant portion of the program.

5. What are the cost sensitive areas?

6. What is the anticipated Morgantown Project cost?

   a. R&D

   b. Test and Evaluation

   c. Capital Grant portion

7. Cost comparison of the maintenance and operation of the PRT system with other ground transportation systems.

8. Why does the Morgnatown Project cost so much?

BACKGROUND

During the long history of urban growth, the role of transportation remained largely undefined. Until about 100 years ago, the world's urban population had only three modes of transportation. They walked, rode horseback or they used a horse and buggy. In succession, we have ~~The last century has~~ seen the introduction of technological improvements: the train, the trolley, the jitney, the bus, the transit train and the automobile. Each of these modes has fortunately had its period of dominance at a time of sharp changes in population distribution and each mode has endured for sufficient time to significantly influence the urban growth.

In the past decades, Urban planners, in their effort to understand the practical impact of their decisions, have carried out intensive studies of the urban growth process and only now are beginning to confirm what has long been suspected - that the quality of urban life and form is deeply influenced by the quality of its transportation. Consequently, transportation was used as a means of shifting or segregating populations for encouraging or discouraging the growth of market centers and for controlling population density.

At the present time, in the low and medium density urban areas, the demand for transportation is predominantly served by the private automobile. It is now essential to focus on new modes of transportation to satisfy today's demand. Recognizing this problem, Congress established the Urban Mass Transportation Administration (UMTA) to

to lead the way

~~provide the leadership to assure~~ in the development of an efficient and coordinated mass transportation systems.

Mr. Villarreal, UMTA's Administrator for the last three and half years is hard at work in providing this leadership, ~~under the general guidance of~~ STET ~~Secretary Volpe~~ STET ~~often~~ ~~Sec. Volpe~~ who recently said that solving of this country's transportation problems in the cities is his number one priority

WHY PRT?

Prior to the UMTA Act of 1964, industry was already studying the increasing transportation demand requirements and the potential market applications of PRT systems. The South Park (Pittsburgh) demonstration began the first phase of demonstration testing in February, 1966. This demonstration was carefully observed by the transit industry through the following years and generated a broad range of interest and conceptual thinking related to the PRT system.

During this period, a number of studies were reviewd by UMTA and numerous approaches to the propulsive method, the guideway scheme, the vehicle suspension and control and communication systems were investigated.

In 1969, UMTA set in motion a plan to survey and categorize PRT systems to provide a "baseline" system description of the most economic and technically most advanced systems. This undertaking involved surveying 126 new systems which ranged in development from concepts and paper designs to some full-scale mockups and prototype operations. It also included detailed baseline description for the ten most promising systems. The survey identified the following prerequisite characteristics:

- An exclusive right-of-way (dedicated guideway).
- Automatic controls (computer).
- Small, individualized vehicles.
- Short headways (short distance between vehicles).
- Quiet suspension and propulsion mechanisms.

Looking further, we find that PRT systems are tailored to serve areas of medium to low population density which are, at the present time, predominantly served by the private automobile. Public transit trunklines may traverse these areas, but service is poor if it exists at all. Increasing travel demands, unmet by public transportation services, tend to encourage multiple-automobile ownerships and uses; often these additional automobiles can be neither afforded nor efficiently accommodated in the metropolitan areas.

At a time when emphasis is on combatting pollution, avoiding congestion, closing of Central Business Districts (CBD) to automobile traffic, a new mode of transportation is required to efficiently accommodate the needs of the urban population. This system has to provide access and service to many potential origins and destinations in a metropolitan area and has to be designed to be more responsive to the requirements that the varying population density and land use pattern indicate.

It is our belief that the PRT integrated with and into the other network modes will provide a desired relief of these problems. Thus, PRT would enhance public transportation by providing faster, more personalized service to the potential traveler. The capability to transport the traveler very close to his desired destination on an acceptable schedule is expected to produce high utilization as well as increased ridership of the PRT system. It is also important to recognize that the operating cost may be greatly reduced in the PRT system since it does not use onboard operating personnel.

Ideally, such a system would give travelers a higher degree of privacy in the demand mode than any other public transit system, although during peak periods in cities with particularly heavy corridor movements a traveler would have to share vehicles with other passengers when scheduled operations were in effect.

WHY MORGANTOWN?

The University of West Virginia received an UMTA grant in 1969 to study the feasibility of constructing a rapid transit system in Morgantown. As a result of this study, in August of 1970, the University submitted to UMTA a capital grant application to install a PRT system linking the Evansdale with the Downtown campus. The University recommended the Alden system among the three competing systems it considered as being the best suited to succeed in Morgantown. In its application, the University outlined a PRT system which in many ways corresponded to UMTA's requirements in terms of innovations and achievability of objectives. The climatic and topographic environment was sufficiently severe to be representative of the great majority of U.S. cities with frequent traffic peaks to serve as a good location for a rigorous operational test undertaking. The University asked in its application to conduct the project under its own management. In order to achieve national relevance, tighter experimental design and development of reproducible (in other geographical locations) equipment, facilities and methods, UMTA decided to retain management responsibility for the project. The commonality of interest was sufficiently strong to produce agreement between UMTA and the University in which the University would make its own real estate available and acquire either possession of additional properties or the necessary rights-of-way at no cost to the project. In view of the community

and university interest exhibited and of the groundwork already accomplished, UMTA found the conditions suitable for giving a go-ahead for the project. In addition, from UMTA's point of view, the Morgantown demonstration was to prove the system out in an urban environment as a true transit link rather than an exhibition of prototype equipment in a laboratory environment like the South Park project and to observe and evaluate user acceptance in actual passenger service operation.

It should not be forgotten that as the result of these objectives, the largest part of the total project cost is related to items and activities which by themselves are not innovative but are necessary as background and basis for the innovations to be tested and demonstrated.

WHAT IS THE PROGRAM MANAGEMENT OFFICE (PMO) DOING TO REDUCE PROJECT COSTS?

Ever since conception of this program, cost reduction has been given priority consideration. The PMO, in cooperation with URD, initiated generic studies such as Minimizing New System Cost and Cost Estimation of Future Systems. In addition, tradeoff studies were conducted such as hot water vs. electric heating, concrete runway surface vs. steel grating, coupled cars vs. single vehicle operation, etc. for the purpose of reducing project costs. Furthermore, continuous system design reviews are conducted with the purpose in mind to assure ourselves that the design is economically viable and technically correct. Excessive cost features receive close scrutiny, hoping to find a cheaper way of accomplishing the same objectives. Various other project management techniques are utilized to provide the necessary visibility to detect cost, schedule and technical changes early enough to take corrective action. This PMO emphasis is not limited to the 3-station, 10-vehicle system only, but for the entire system and also future system reproduction, bearing in mind all the time the need to meet the October 1972 demonstration schedule.

To provide the management visibility necessary to accomplish this, the prime contractor has been required to submit his planned manpower, cost and development schedule for each

month throughout the life of this project. Monthly progress reports then indicate how work is progressing in comparison to that planned in each separate area (Management, Vehicle Control and Communications, and Structures and Power). Problems in cost and/or schedule are quickly identified and appropriate action taken.

Since written reports do not always adequately portray project status, monthly reviews have been used together with informal and personal liaison to insure program office knowledge of all facets of the program. As a result of these meetings, when additional verification was desirable to satisfy the PMO that the proposed solution to a problem was the correct one from a technical and economic standpoint, specific studies were undertaken by the contractor at the PMO's request.

<u>To date, over 162 such studies and 78 action items have been instituted by the PMO.</u>

The combination of these PMO's efforts resulted in (a) elimination, (b) reduction, or (c) deferral of specific items, representing a cost reduction (from both the R&D and capital grant portions of the program) totaling well over 10 million dollars.

The following represent some of the items in each category not necessarily in order of importance:

a. Elimination or major design changes.

1. Eliminated requirements for training (coupling) of cars.
2. Eliminated public information support requirements.
3. Eliminated fully enclosed, air-conditioned stations.
4. Eliminated elevators and moving stairs.
5. Changed requirements from 1100 passengers - 10 minutes to 1100 passengers - 20 minutes.
6. Eliminated maximum allowable waiting requirements at station.
7. Eliminated computorized management information system.
8. Use of hot water rather than electricity for guideway heating resulted in reduction of cost not only in the annual operating cost, but significant cost reduction also in the capital investment.
9. Reduced the vehicle size from 30 ft to 15.5 ft. Interior designed to permit standees and wheelchairs too, rather than only seating arrangement.
10. Eliminated communications status monitor capability from the communication units (computer interrogation of operational status).
11. Eliminated ramp tone transmitter (speed change profile).
12. Eliminated software collision avoidance (redundancy remained in the form of the block system and the point follower system.

13. Eliminated the requirements for "realtime" diagnostic routine (self-test).
14. Eliminated TV requirements at stations.
15. Eliminated redundant computer requirement as well as other C&CS redundant equipment without compromising reliability/availability requirements.
16. Eliminated recovery vehicle requirements.
17. Eliminated storage requirement of time origin/destination information (for scheduling following day's activity and evaluation of system usage).
18. Eliminated anti-skid braking requirements.
19. Eliminated training room requirement.
20. Eliminated control center at Engineering Station.
21. Eliminated parking lot and yard lighting at maintenance.
22. Eliminated center drainage of guideway at interchange area.
23. Deleted vehicle reverse capability requirement.
24. Deleted two-wheel steering during high speed operation.
25. Eliminated facia on guideway along B&O railroad.
26. Eliminated redundancy in electrical system.

b. Reduced requirements or changed design which resulted in cost reduction:

1. Reduced the number of "fault isolation channels" from 32 (16 for the vehicle and 16 for the VC&CS) to 6 channels.

2. Reduced number of slots from 4 to ~~3~~ per channel - instrumented only first position - option is open for fourth slot without major work.

3. ELIMINATED Reduced system displays and automatic controls to minimum commensurate with system operations.

4. Reduced quantity of prototype vehicles from 15 to ~~10~~ 5.

5. Reduced software requirements to satisfy three stations, ~~10~~ 5 vehicle configuration.

6. Reduced cost by increasing headways from 7.5 seconds to 15 seconds interval without jeopardizing 1100/20 requirements.

7. Reduced maintenance building area.

8. Reduced length of retaining wall at maintenance.

9. Reduced length of guideway at maintenance.

10. Reduced cost by modifying underpass at interchange area (eliminated tunnel).

11. Reduced Structures and Power requirements.

12. Reduced cost by changing the route lay-out and building part of the guideway on-grade.

13. Reduced cost by utilizing expanded metal instead of steel grating on walkways.

14. Reduced cost by negotiating with Boeing to pay for the Kent, Washington Test Track from their corporate funds.

c. Deferred from R&D portion.

1. Deferred boiler substation procurement and installation.
2. Deferred installation of prime electrical power substations for full-up system. (only 3 substations will be installed.)
3. Deferred maintenance facility permanent structure. Butler type building will be used.
4. Deferred procurement at this time of standard tools.
5. Deferred voice communication for the 10 vehicles. (Provided spare CRT breaker at station and space for controls on central control consoles.)
6. Deferred procurement of fare collection.
7. Deferred procurement of diagnostic test sets.

WHAT ARE THE COST SENSITIVE AREAS?

In order of priority:

a. Guideway

b. C&CS

c. Vehicle

Reasons:

a. Looking at the Morgantown program for the purpose of identifying cost sensitive areas you cannot help but be overwhelmed by the cost of the construction of the guideways and stations (alias "Structures and Power" or "brick and mortar") costs. Early engineering estimates were very misleading. Later estimates, based on schematic drawings were way out also. This part of the program cost overshadows all other costs and is more sensitive to miscalculations - a small percentage of error in estimating has serious cost consequences of the overall construction cost.

b. Number two on the list of priorities is of course the C&CS. Not so much the individual electronic hardware cost, but more the installation of the large quantity of sensors, detectors, wires and other electronic equipment required for an automated system along the 11,000 feet of double guideway and stations. (The length of wire alone is close to 1.5 million feet.) On the other hand, a significant part of the C&CS cost includes the cost of the software development, the algorithm development and

their simulation and checkout. The success of the systems operation depends on how well the algorithm is developed, how well the empty cars are managed (to reduce car mileage), how well the system is able to satisfy peak demand requirements, how well the station operation is managed, when to merge and when to demerge and the control and communication commands to accomplish all these in an orderly fashion. This development requires time, brain-power, imagination and a lot of computer time. Once the system algorithm is developed and simulated the actual programming of the software is "semi-routine" but is not very costly. In view of the above, the cost sensitivity of this subsystem can be summarized as quantity of electronics gears and their installation and tedious software development.

c. Next, in order of priorities, is the vehicle. However, little fluctuation appears in the cost between the original first estimates and the current prognasticatíons. Therefore, it is safe to assume that the cost of the vehicle is the least sensitive part of the program.

NOTE: The car size (i.e., the number of passengers in a car) has a direct relation to the system operational headway allowing an increase in the time interval from 7.5 seconds to 15 seconds without endangering the 1100/20 requirements.

JPL study based on 25% load factor. TSC study based on 10% load factor. ~~An exp~~

Using the TSC method with a 25% load factor gives approximately 9¢ per passenger mile. Difference between auto cost not determined. should use 9¢/mile

12/7/71 [illegible]

Comparison of the maintenance and operation costs of the PRT system with other ground transportation systems.

Cost studies have been conducted in UMTA Morgantown Project Office as well as other places in the Department to compare capital, operating and maintenance cost of various ground transportational systems. The dual-mode draft study is presently under review by DOT/UMTA. This study addresses among other things the cost of various ground transportation systems and forms a comparison between a number of different ground modes of transportation. The comparison shows cost per passenger mile considering such cost items as stations, guideways, vehicles, maintenance, operations, taxes, debt service and operating personnel. The costs were established on a comparable basis and reflect not only a fair comparison but also a reasonably accurate cost data point. The results are as follows:

System	Dollars Per Passenger Mile
Captive pallet	$.043
Modified private auto	.074
MORGANTOWN	.087
PAAC	.093
AB&W bus	.100
Priority bus lane	.100
Metro (Washington, DC)	.140

Why

As a point of comparison, TSC submitted data from a preliminary study they prepared which indicates the following:

Private Automobiles	$.15 to $.25 per passenger mile
Morgantown	.21 per passenger mile

us

The conclusion to be drawn from the above is that PRT systems in general and the Morgantown System in particular, are economically and operationally viable and in a good competitive position when compared with other ground transportation systems. (See attachment)

Morgantown Six Station System with 70 Vehicles

Costs - (Thousands)

	R&D	CAPITAL GRANT
Vehicle	$ 3,217	(low) $ 2,100
C&CS	5,025	(high) 5,200
Guideway & Stations	14,951	(high) 14,000
Installation & Checkout	1,518	1,500
Program Management	1,389	(low) 500
Fee	1,311	(low) -
	$27,411	$23,300

TOTAL COSTS

70 Vehicles	$ 5,317	
C&CS	10,225	high
Guideway & Stations	28,951	
Installation & Checkout	3,018	
Program Management	1,889	
Fee	1,311	
	$50,711*	

$50,711	TOTAL
5,317	VEHICLE
44,394	All other Costs

*Does not include Test & Evaluation nor JPL expenditure. (where does that show up?)

* Morgantown Costs - Based on Total R&D Plus Capital Grant Funding. Assume 2/3 of Total Costs Contributed by UMTA.

		Per Year	Per Passenger Mile
Central Control		$ 205,000	$ .0080
Administrative		128,000	.0050
Vehicle	Maintenance	232,000	.0090
	Power	102,000	.0040
	Interest Depreciation	186,667	.0073 *
Guideway	Maintenance	52,200	.0020
	Power	128,000	.0050
	Interest Depreciation	1,056,667	.0486 *
		$2,090,534	$ .0889

Morgantown operating costs based on R&D being sunk costs and balance of system being capital grant. These costs reflect operating costs for operator who has to put up 1/3 of capital grant investment.

	Per Year	Per Passenger Mile
Central Control	$205,000	$ .0080
Administrative	128,000	.0050
Vehicle		
Maintenance	232,000	.0090
Power	102,000	.0040
Interest, Depreciation	73,822	.0029
Guideway		
Maintenance	52,200	.0020
Power	128,000	.0050
Interest, Depreciation	505,000	.0197
	$926,022	$ .0556

This is a realistic forecast of the actual costs to the University of West Virginia based on R&D being sunk costs.

Only estimate before this
was the $13.5m of WVU.
Until early 1971, JPL
did not have a system
design to cost out.

We (DOT) earlier
estimated $20 million
for the project (This was
only an intuitive
"guestimate".)
12/8/71 gsw

Why does the Morgantown Project cost so much?

In mid-1970, the decision was made to develop and demonstrate the first PRT system in Morgantown along the line of the objectives as stated in Chart A.

The most cost-sensitive objective is the one concerned with measuring public and user acceptance (modal split). It means that the demonstration has to be conducted in an urban area rather than in an unpopulated test site. The nature of the system (automatic) requires a dedicated guideway. The desire to provide passenger service to measure user acceptance dictated a minimum geographic extent and transportation capacity of the installation to make it a true transit link rather than a prototype exhibition like the South Park Project.

As a result of these objectives a large part of the total project cost is related to items and activities which by themselves are not innovative but are necessary as background and a basis on which to test and demonstrate the innovations.

what about estimates before this time - [illegible]

Early in 1971, the first realistic cost estimate of 37.5 million dollars for a total 6-station system became available indicating the need for reduction of scope and innovation content. In April 1971,

SAM is looking
for the info on
Construction Cost
for Hiways, Subway
Westinghouse PAAC -
express bus lanes
etc.

for a 3-station demonstration

JPL proposed a reduced scope project estimating its cost in the order of 23.5 million dollars. Under the pressure of the October deadline, a complete reorientation and redesign of the system was not considered as a feasible alternative and the project was approved on this basis. Later events indicated that both numbers were too low, necessitating the need to reduce cost further.

(Let's continue to spell out cost history

A sizable part of the various cost reductions was achieved by cutting out innovative features which, though desirable, are not absolutely necessary to meet the stated project objectives, but could be crucial to the economic feasibility of the system in other locations. Further cuts in the innovative features of the project will quickly reduce the innovation content to a point where the resulting ration of "innovation value" to "total project cost" will make it difficult to justify the project as an R&D activity.

The question has been raised whether or not the concept is viable as a transit system in view of its high cost of initial investment. While it is too early to produce accurate cost projections before the competition for the facilities construction is over, we have made some preliminary estimates. According to these, and depending on location, it should be possible to reproduce a Morgantown System for $10 million/mile all inclusive. This system

Can we include table here showing construction [illegible] comparative construction [illegible] per mile?

should have a peak capacity of 6-8000 passengers per hour. Within certain limits the cost is not very sensitive to the capacity and can certainly be increased to 10,000 per hour without a substantial increase in cost. With these numbers it compares with the planned Transit Expressway Revenue Line which projects an all inclusive cost of $18M per mile to generate an ultimate peak capacity of up to 20,000 passengers/hour without, however, having the demand-responsive feature and schedule flexibility of the Morgantown System.

In any comparison it should be recognized that the installation of a new PRT system means the generation of additional transportation capacity along a vehicular traffic artery equal to an additional multi-lane highway without tearing down residences or places of business along its path and creating more pollution and downtown congestion.

OBJECTIVES

Program Objectives

- Provide acceptable alternatives to the private car to reduce congestion as well as air and noise pollution

- Provide tested options outside the present spectrum of mass transit systems, qualified for capital grants

PRT Objectives

- Increased frequency, punctuality and flexibility of service

- Reduce impact of wage rates on fares

- Emphasize circulation and distribution mission

Objectives of Demonstration Projects

- Determine

    ° Technological maturity

    ° Cost of maintenance and operation

    ° Degree of public acceptance (modal split)

- Qualify system for capital grants

Specific Objectives for Morgantown Project

Self-service
Short headways (5 - 10 seconds)
On-vehicle switch
Merging and de-merging
Off-line Stations
(System performance in car-intercept mode)